Scientific Excellence • Resource Protection & Conservation • Benefits for Canadians
Excellence scientifique • Protection et conservation des ressources • Bénéfices aux Canadiens

Larval Lobster (Homarus Americanus Milne Edwards) Distribution in a Protected Scotian Shelf Bay

C. DiBacco and J.D. Pringle

Benthic Fisheries and Aquaculture Division
Biological Sciences Branch
Department of Fisheries and Oceans
P.O. Box 550
Halifax, Nova Scotia B3J 2S7

1991

Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 2110

Fisheries and Oceans Pêches et Océans

Canada

Canadian Manuscript Report of Fisheries and Aquatic Sciences

Manuscript reports contain scientific and technical information that contributes to existing knowledge but which deals with national or regional problems. Distribution is restricted to institutions or individuals located in particular regions of Canada. However, no restriction is placed on subject matter, and the series reflects the broad interests and policies of the Department of Fisheries and Oceans, namely, fisheries and aquatic sciences.

Manuscript reports may be cited as full publications. The correct citation appears above the abstract of each report. Each report is abstracted in *Aquatic Sciences and Fisheries Abstracts* and indexed in the Department's annual index to scientific and technical publications.

Numbers 1–900 in this series were issued as Manuscript Reports (Biological Series) of the Biological Board of Canada, and subsequent to 1937 when the name of the Board was changed by Act of Parliament, as Manuscript Reports (Biological Series) of the Fisheries Research Board of Canada. Numbers 901–1425 were issued as Manuscript Reports of the Fisheries Research Board of Canada. Numbers 1426–1550 were issued as Department of Fisheries and the Environment, Fisheries and Marine Service Manuscript Reports. The current series name was changed with report number 1551.

Manuscript reports are produced regionally but are numbered nationally. Requests for individual reports will be filled by the issuing establishment listed on the front cover and title page. Out-of-stock reports will be supplied for a fee by commercial agents.

Rapport manuscrit canadien des sciences halieutiques et aquatiques

Les rapports manuscrits contiennent des renseignements scientifiques et techniques qui constituent une contribution aux connaissances actuelles, mais qui traitent de problèmes nationaux ou régionaux. La distribution en est limitée aux organismes et aux personnes de régions particulières du Canada. Il n'y a aucune restriction quant au sujet; de fait, la série reflète la vaste gamme des intérêts et des politiques du ministère des Pêches et des Océans, c'est-à-dire les sciences halieutiques et aquatiques.

Les rapports manuscrits peuvent être cités comme des publications complètes. Le titre exact paraît au-dessus du résumé de chaque rapport. Les rapports manuscrits sont résumés dans la revue *Résumés des sciences aquatiques et halieutiques*, et ils sont classés dans l'index annuel des publications scientifiques et techniques du Ministère.

Les numéros 1 à 900 de cette série ont été publiés à titre de manuscrits (série biologique) de l'Office de biologie du Canada, et après le changement de la désignation de cet organisme par décret du Parlement, en 1937, ont été classés comme manuscrits (série biologique) de l'Office des recherches sur les pêcheries du Canada. Les numéros 901 à 1425 ont été publiés à titre de rapports manuscrits de l'Office des recherches sur les pêcheries du Canada. Les numéros 1426 à 1550 sont parus à titre de rapports manuscrits du Service des pêches et de la mer, ministère des Pêches et de l'Environnement. Le nom actuel de la série a été établi lors de la parution du numéro 1551.

Les rapports manuscrits sont produits à l'échelon régional, mais numérotés à l'échelon national. Les demandes de rapports seront satisfaites par l'établissement auteur dont le nom figure sur la couverture et la page du titre. Les rapports épuisés seront fournis contre rétribution par des agents commerciaux.

92-02083/

Canadian Manuscript Report of
Fisheries and Aquatic Sciences 2110

1991

LARVAL LOBSTER (*HOMARUS AMERICANUS* MILNE EDWARDS) DISTRIBUTION IN A PROTECTED SCOTIAN SHELF BAY

C. DiBacco and J.D. Pringle

Benthic Fisheries and Aquaculture Division
Biological Sciences Branch
Department of Fisheries and Oceans
P.O. Box 550
Halifax, Nova Scotia
B3J 2S7

© Minister of Supply and Services Canada 1991

Cat. No. Fs 97-4/2110E ISSN 0706-6473

Correct citation for this publication:

DiBacco, C. and J.D. Pringle. 1991. Larval Lobster (Homarus americanus Milne Edwards) Distribution in a Protected Scotian Shelf Bay. Can. Manuscr. Rep. Fish. Aquat. Sci. 2110: 26 p.

CONTENTS

Abstract iv

Introduction 1

Material and Methods 2

Figure 1 3

Figure 2 4

Results 5

Figure 3. 6

Figure 4. 7

Discussion 8

Table 1 9

Figure 5 10

Figure 6 11

Acknowledgements 13

References 14

Appendix A 17

Appendix B 18

Appendix C 19

Appendix D 20

Appendix E . . . . . 21 & 22

ABSTRACT

DiBacco, C. and J.D. Pringle. 1991. Larval Lobster (Homarus americanus Milne Edwards) Distribution in a Protected Scotian Shelf Bay. Can. Manuscr. Rep. Fish. Aquat. Sci. 2110: 26 p.

The hypothesis that lobster larvae occur within the confines of Jeddore Harbour, a sheltered embayment on Nova Scotia's southeastern shore, is tested. Though little is known about larval distribution along the Scotian Shelf, workers have hypothesized that warmer temperatures and possibly enhanced food availability within these protected embayments would enhance larval survival. Sampling, using twin, one-meter square (m^2), flowmeter-equipped neuston nets, was carried out from mid-afternoon to early the following morning once weekly, over ten weeks, commencing July 21 and terminating September 22, 1988. Water temperature, salinity and light intensity were measured concurrently. Seventy-nine surface tows, with a mean duration of 24.2±4.18 min. at between 0.7-1.0 ms^{-1} (~1.4-2.0 knots), were completed. Eighteen tows yielded an average of 2.63 lobster larvae per tow; stage 1 larvae only were observed. Significantly more larvae were captured during nighttime than during daytime tows. Peak abundance occurred during the week of August 4 when 115 of a total number of 208 larvae were sampled. Failure to collect later stage larvae and the post-larval stage suggests their absence from the sampled portion of Jeddore Harbour. The post-stage 1 larvae either migrated to areas of the harbour not sampled (inaccessible to the sampling equipment) or were flushed from the harbour. The harbour's flushing rate, calculated at 4.41 tide cycles (approximately 60 h), supports the latter hypothesis, as does the occurrence of the majority of larvae at the seaward end of a deep narrow channel contiguous to the harbour mouth.

RÉSUMÉ

DiBacco, C. and J.D. Pringle. 1991. Larval Lobster (Homarus americanus Milne Edwards) Distribution in a Protected Scotian Shelf Bay. Can. Manuscr. Rep. Fish. Aquat. Sci. 2110: 26 p.

On vérifie l'hypothèse selon laquelle des larves de homard seraient présentes dans le port de Jeddore, une baie abritée de la côte est de la Nouvelle-Écosse. Bien que l'on ne sache pas grand-chose de la distribution des larves le long de la plate-forme néo-écossaise, certains ont conjecturé que les températures plus chaudes et la plus grande abondance possible de nourriture au sein des baies protégées pouvaient être propices à la survie des larves. On a donc prélevé des échantillons au moyen de filets jumeaux à neuston de un mètre carré munis d'un débitmètre et cela une fois par semaine entre le milieu d'un après-midi et le début de la matinée suivante, du 21 juillet au 22 septembre 1988, soit pendant dix semaines. Au cours de ces expériences, on a mesuré en même temps la température, la salinité et l'intensité lumineuse de l'eau. On a effectué soixante-dix-neuf traits en surface, d'une durée moyenne de 24,2±4,18 min, à environ 0,7-1,0 ms^{-1} (~1,4-2,0 noeuds). Dix-huit traits ont produit un rendement moyen de 2,63 larves de homard par trait. Les échantillons ne contenaient que des larves du premier stade. Fait important à noter, on a capturé plus de larves la nuit que le jour. L'abondance larvaire a atteint son summum la semaine du 4 août, durant laquelle on a échantillonné 115 larves sur un nombre total de 208. L'absence de larves de stade plus avancé et de juvéniles post-larvaires dans les échantillons semble être révélatrice de leur inexistence dans la partie du port de Jeddore étudiée. Soit que les larves ayant dépassé le premier stade ont migré vers les secteurs du port qui n'ont pas été échantillonnés (secteurs inaccessibles au matériel d'échantillonnage), soit que l'action de chasse d'eau les a poussées hors du port. Or, le taux de renouvellement des eaux du port, établi à 4,41 cycles de marée (environ 60 h), milite en faveur de la dernière hypothèse, comme d'ailleurs le fait que la majorité des larves se trouvent de côté de la mer, à l'extrémité d'un chenal étroit et profond contigu à l'entrée du port.

INTRODUCTION

Commercial lobstering (Homarus americanus Milne Edwards) was introduced to Canada's Maritime provinces by 1851 (Pringle et al. 1983), it since has become the area's most lucrative fishery. A decade later this fishery experienced appreciable demands due in part to declining American catches. Fishing pressure increased until severe declines in total landings resulted (Robinson 1979). Regulations, aimed at controlling fishing effort, were first implemented in 1877 (Dewolf 1974). Demand is still high, thus a recent study was commissioned (Anon. 1989) to review the fishery as a first step in developing a revised management plan. Large, yet unexplained fluctuations in annual yields, as experienced in the 1960's and 1970's along Nova Scotia's eastern shore [Lobster Fishing Areas (LFA's) 32 and 33] (Fig. 1) (Pringle and Duggan 1985), are an indication of our need to better understand environmental and ecological factors influencing lobster stocks.

The planktonic larvae are believed to be a critical aspect of the life cycle of Homarus americanus in terms of understanding stock recruitment (Dadswell 1979; Harding et al. 1979, 1982, 1983, 1987; Stasko 1980). The larvae develop over about 10.5 mo within eggs externally attached to the female's pleopods (Herrick 1911). The larvae, after egg hatch, rise to the near surface waters. Larval development occurs during the first two molts; these stages have both a morphology and behaviour distinct from the adult. The third molt induces a metamorphosis to the post-larval form (Cobb, pers. comm.), which closely resembles the adult morphology. It maintains the pelagic lifestyle for a portion of this stage only, and then adopts the benthic mode (Cobb et al. 1989).

The larval and post-larval stages yield the lobster's largest growth rates with respect to size and weight (Wilder 1953) and also exhibit its greatest morphological changes (Herrick 1911). The importance of these stages to year class strength (for example, recruitment to commercial sized lobsters) has lead to the development of an array of factors thought critical to larval growth rates and molt frequency. Among the suggested factors playing a crucial role are water temperature (MacKenzie 1988; Templeman 1936), salinity, light intensity, food availability (Templeman 1936) and water quality (Wells 1976; Wells and Sprague 1976). Harding et al. (1983), with these factors at the for, hypothesized that, as opposed to the exposed coast, Nova Scotia's eastern shore bays may provide the warmer temperatures and more adequate supplies of plankton (for example, food) required to enhance larval survival. Unfortunately, little lobster larval work has been carried out in northwest Atlantic bays.

Fishermen of Jeddore Harbour, an eastern Nova Scotia bay (Fig.1), have shown a keen interest in lobster resource science. This, and its close proximity to Halifax-based scientists, prompted its choice for a long term study on lobster population biology. Recently, large berried female lobsters were observed in this harbour just prior to larval hatching (Duggan and Pringle 1988; Jarvis 1989). Commercial lobster yields within this entire Lobster Fishing Area (32) the past few decades, have been lower than contiguous LFA's. Fishermen's concerns about the decline of the fishery prompted attention from the scientific community (Dadswell 1979; Robinson 1979; Wharton and Mann 1981; Harding et al. 1983; Pringle and Duggan 1984, 1985; Duggan and Pringle 1988; Jarvis 1989). Duggan and Pringle (1988) suggested Jeddore Harbour as a source of brood stock. Jarvis (1989) tracked the movement of berried females in relation to Jeddore Harbour. The primary question addressed by the present study was whether lobster larvae occur in Jeddore Harbour, and if so, to determine their temporal and spatial distribution over time.

SAMPLING SITE

Sampling was carried out in Jeddore Harbour, a marine embayment located on Nova Scotia's South Eastern Shore (Fig. 1). It consists of an inner bay (~2.5 km long by 1.3 km wide, with an average depth of 3 m) (Fig. 1), characterized by many shallow eelgrass beds and rocky shoals. The bay is linked to the outer harbour, and open ocean, by a deep, narrow channel (~4 km

long with an average width of 60 m and an average depth of 6 m). Sampling was carried out on both the eastern side of the inner bay and in the channel out to Marsh Point (Fig. 1). Surface temperatures within the harbour and the channel ranged from 5.4 °C to 18.4 °C, while bottom temperatures varied between 4.2 °C to 17.2 °C for the months of May through September, 1988 (Jarvis 1989). Surface salinities measured over the same time period varied from 20°/oo to 31°/oo (Jarvis 1989). Inner bay currents were weaker than those in the channel. Jeddore had a mean tidal range of 1.05 m during the study period, July 21 to September 22, 1988.

MATERIALS AND METHODS

Plankton was simultaneously sampled with two, one-meter-square neuston nets towed from side booms mounted on the port and starboard sides of a 6.1 m boat (Fig. 2). The 1.5 m booms allowed the nets to sample water relatively undisturbed by the boat's turbulence. Nets were constructed from 1600 µm grade Nitex mesh, giving a pore to mouth area ratio greater than three (Tranter and Smith 1968), thus increasing their filtering efficiency. This pore size retained normal-sized stage 1 lobster larvae (P. Vass, pers. comm., Research Biologist, Department of Fisheries and Oceans, Bedford Institute of Oceanography, Dartmouth, Nova Scotia, Canada). A General Oceanic flowmeter was rigged in the mouth of each net, permitting calculation of the volume of water filtered. Tow line length was adjusted to position the net top about five cm above the water's surface. The area sampled is shown in Fig. 1; the non-sampled area was too shallow for the equipment available. The Harbour's dimensions restricted average tow length to 24.2 min$\pm$4.18 min, at speeds which varied between 0.7 to 1.0 m $\cdot$ sec^{-1} (~1.4 to 2.0 knots). Large accumulations of eelgrass in the nets required some tows to be shortened, and abandoned on two occasions. Large, unattached eel grass patches were avoided. Eel grass sampled was either thoroughly washed and discarded or preserved and sorted in the lab for larvae. Samples were collected one day per week from July 21, 1988, when egg-hatch was first observed (Jarvis, pers. comm.), to September 22, 1988, when catch rates fell to low levels. Samples were collected from mid-afternoon (~1400 h) to early morning (~0100 to 0200 h) of the following day. Each sampling session consisted of seven to eleven paired tows. Light (daytime) period samples, for example, where light meter readings were above zero, were distinguished from dark (nighttime) period samples. Stations to be sampled once per cruise were usually sampled during darkness, while other stations were sampled during both light and dark periods. Note that light intensities were not quantified on the dates of July 21, August 24 and September 1 and that daytime versus nighttime tows for these dates were estimated.

During the studies early weeks, stations were positioned to cover as much of Jeddore Harbour as was feasible. Later, effort was concentrated at stations consistently yielding the greatest larval numbers. The remaining sites were only periodically sampled. Subsurface/surface light intensities, surface temperatures and surface salinities were recorded for most tows, using a LICOR quantum meter (model LI-185-B) and underwater sensor (model LI-192 SB), a time delayed locking temperature probe, and a refractometer, respectively.

The nets were raised to the boom after each tow and washed with water thrown at the nets exterior. The nets distal and cod ends were washed with pumped water. The concentrated samples were transferred to 1.7 l jars containing a 5% formaldehyde seawater solution buffered with sodium borate. Collected larvae were staged, according to Herrick's (1911) descriptions, with the aid of a dissecting microscope.

The data were transferred to computer and analyzed for normality using the SYSTAT statistical package (Wilkinson 1987).

Significance ($P \leq 0.05$) within the data was determined using the Mann-Whitney U-statistic (for example, comparing the number of larvae captured during nighttime versus daytime towing), the Chi-Square test of independence (for example, comparing the number of larvae captured in three different regions of

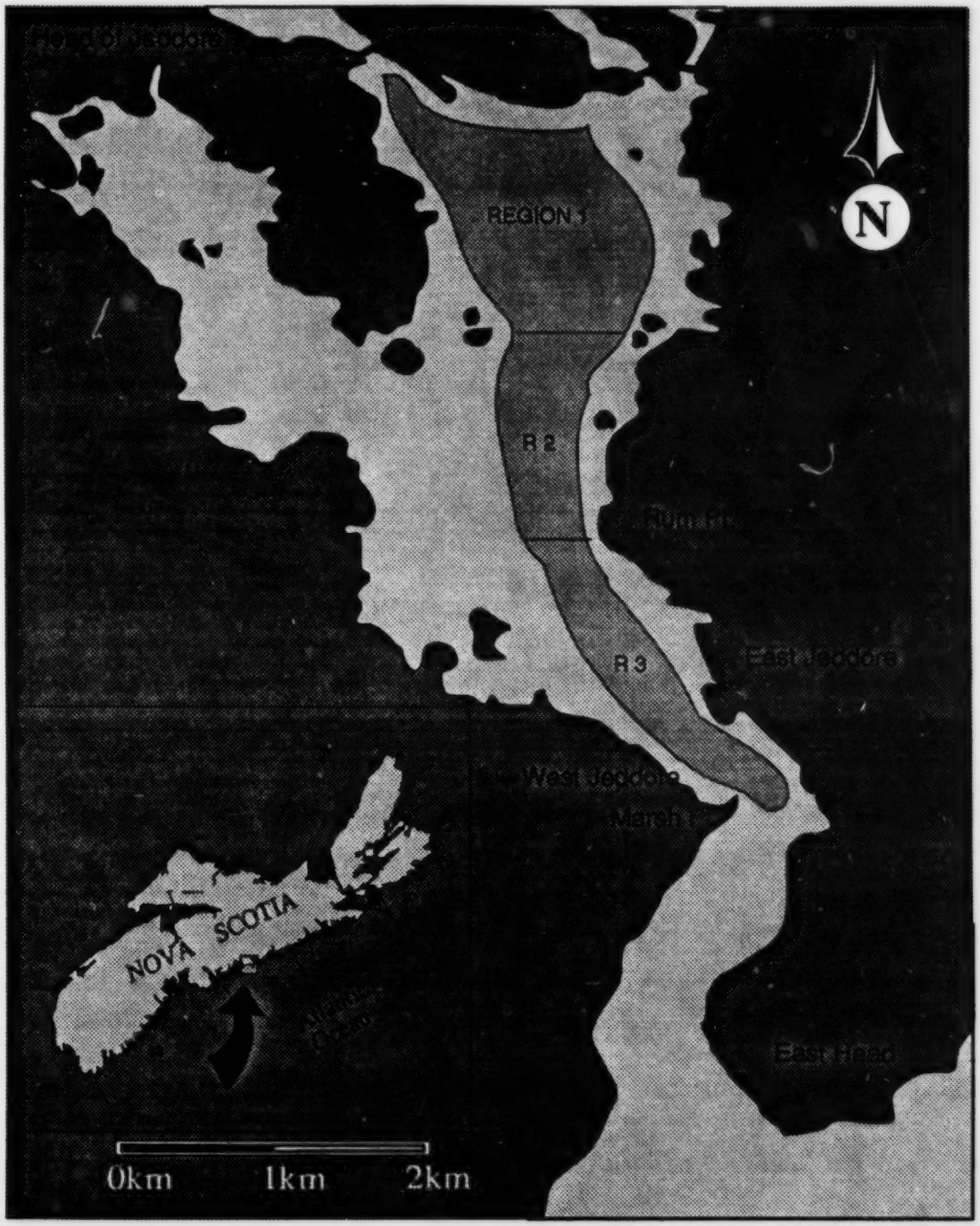

Figure 1: General configuration of Jeddore Harbour consists of an inner bay linked to the open Atlantic Ocean by way of a deep narrow channel. The shaded portion of the harbour (Regions 1, 2 & 3) represents the sampled area. The inset highlights Jeddore Harbour's southeastern location and Nova Scotia's Lobster Fishing Areas (LFA's) 29 - 33.

Figure 2: The port one-meter-square neuston net being towed from the research vessel 'Rapture' in Jeddore Harbour.

the harbour) and Friedman's two-way analysis of variance (for example, testing for any correlation between the number of larvae sampled and temperature, salinity, light intensity and/or the date of sampling) (Siegel 1956).

The flushing rate (for example, flushing time) of Jeddore Harbour was estimated using the following relationship:

$$1/e = (V/(V+P))^n ,$$

where 'V' represents the harbour's low tide volume; 'P', the intertidal volume; 'e', the base of natural logarithms (=2.7182818) and 'n', the number of tide cycles required to flush the bay in question (Dr. R. Trites, pers. comm., Research Scientist, Department of Fisheries and Oceans, Bedford Institute of Oceanography, Dartmouth, Nova Scotia, Canada).

Low tide volume was calculated by dividing Jeddore Harbour into horizontal layers defined by the 0 m, 3.66 m, 7.32 m, 10.97 m and 14.63 m depths. Area was calculated at each depth using a Hewlett Packard digitizer (model #9874A) and a Hewlett Packard terminal (model #9825). The final volume of each layer was obtained from the following formula:

Vol. of layer = [(Area of top layer + Area of bottom layer) / 2] (Thickness of layer)

The volumes summed is a good estimate of the harbour's low tide volume. The intertidal volume was calculated by multiplying the low tide area of the harbour with the intertidal height. The latter 'value' will vary from day to day and therefore was calculated by averaging the change in tide heights for the larval sampling period, July 21-September 22, 1988, using the tide tables (Anon. 1988) for Jeddore Harbour.

RESULTS

The time and length of each tow as well as its position within the harbour is presented in Appendix E. Seventy-nine paired tows were made during the study; surface temperature, surface salinity and sub-surface light intensity was quantified for 72, 51 and 63 of these tows, respectively. Surface water temperature ranged between 18.0 °C (1/9/88) and 10.8 °C (15/9/88) (Appendix A) with an overall mean of 15.31 °C$\pm$1.83 °C. The mean temperature per cruise is given in Figure 3. Mean salinity ranged from 26.0°/oo to 29.5°/oo (Appendix B), with an overall mean of 27.2°/oo$\pm$4.4°/oo). Mean salinity per cruise is given in Figure 4. Sub-surface light intensities varied from 0 $\mu E\ m^{-2}\ s^{-1}$ during nighttime, to 850 $\mu E\ m^{-2}\ s^{-1}$ at mid-afternoon (Appendix C).

Jeddore Harbour low tide volume was $7.76 * 10^7\ m^3$, while both the intertidal range and volume were estimated to equal 1.05 m and $1.97 * 10^7\ m^3$, respectively. The calculated flushing rate was 4.41 tides, spanning approximately 60 h.

A total of 208 larvae, all stage 1 were captured. Larval abundance estimates ranged from 0, in 61 of 79 tows, to a maximum of 37.5 larvae per 1000 m^3 of water filtered (Appendix D). This peak was observed on the night of August 4, when 115 larvae were captured (Table 1). Four larvae only were observed on the initial cruise, July 21, (Table 1); one larva was collected on the final cruise (September 22), following two weeks when none were observed. The sampling scheme permitted testing of the hypothesis that larval catch rates are significantly higher during dark hours than during daylight; 41 and 38 of the total number of tows were conducted during day and night, respectively. The hypothesis was accepted (Fig. 5), even with the exclusion of the anomalously large August 4 sample. Two hundred of the 208 larvae sampled were caught during the dark period. The majority of larvae sampled during nighttime were captured in the two hours immediately following sunset. Daytime catches varied in light intensities from bright sunshine, 620 $\mu E\ m^{-2}\ s^{-1}$ (August 11, 1730h - 1 larva), to overcast conditions, 2.0 $\mu E\ m^{-2}\ s^{-1}$ (August 11, 2040 h - 1 larva).

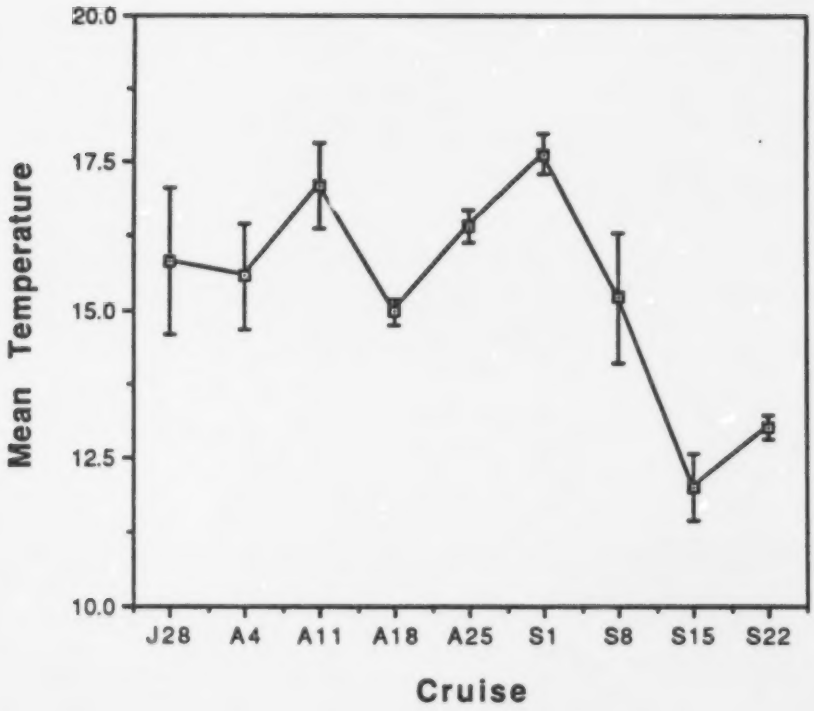

Figure 3: Cruise mean surface water temperatures (°C) where data were available (J=July, A=August and S=September). Vertical lines represent ±1 standard error.

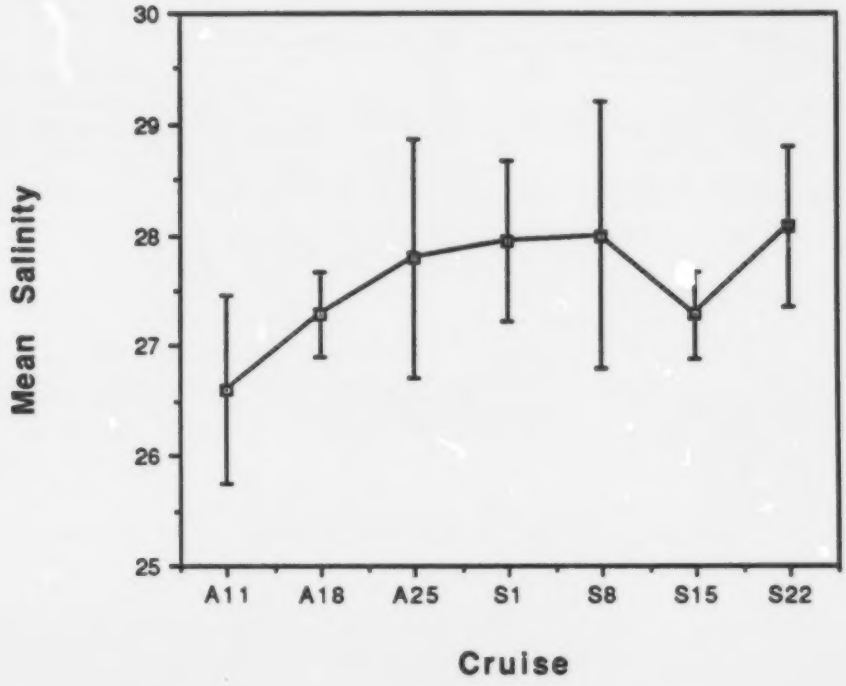

Figure 4: Cruise mean surface salinities (‰) where data were available. (A=August and S=September). Vertical lines represent ±1 standard error.

The sampled portion of the harbour was divided into three regions, (Fig. 1), based on larval abundance and the provision that tows did not overlap two or more regions. Significant differences in larval abundance between areas was observed (Fig. 6): region 1 yielded significantly fewer larvae (14 in 34 tows) than regions 2 (126 larvae in 19 tows) or 3 (68 larvae in 23 tows); there was no significant difference between the latter two regions. The shallow areas, sampled only under appropriate conditions (for example, high tide), yielded no larvae.

No significant correlation was found between the number of larvae sampled and three state variables; water temperature, salinity and light intensity, as well as date of sampling. Also considered as a possible influence on catch rates was the presence of floating debris, especially eelgrass, collected in the neuston nets. Although large patches of eelgrass were avoided, many tows accumulated sizeable quantities; a positive relationship between the presence of larvae and eelgrass was not observed.

DISCUSSION

Duggan and Pringle (1988) and Jarvis (1989) observed berried lobsters, H. americanus, in Jeddore Harbour during the summer, July-September. The finding of stage 1 lobster larvae during this study confirms that hatching and larval release does occur within the confines of this warm, sheltered embayment.

The vertical migratory behavior observed in early-stage lobster larvae (Ennis, 1975) was discussed by Scarratt (1973) and Bibb et al. (1983), who reported larger larval catches in the neuston during daytime compared to nighttime sampling. Their findings are in agreement with the observations of Smith (1937), Templeman (1937), Templeman and Tibbo (1945) and Lux et al. (1983), who suggested the progressive descent of inshore larvae beyond dusk. Contrary to these results, are those of Hudon et al. (1986), Harding et al. (1987) and the present study. All reported significantly larger catches during the dark period. Furthermore, the bulk (>94%) of the larvae were captured in the first two hours following sunset.

Although sampling continued for ten weeks, and for seven weeks following the largest catch rates (August 4), no post-stage 1 larvae were captured. The presence of larvae and berried female lobsters within Jeddore Harbour, might indicate support for the hypothesis that shallow, sheltered embayments are important for egg and larval development and ultimately recruitment to inshore stocks (Harding et al. 1983). These authors proposed that a superabundance of appropriate sized food (for example, plankton) and higher temperatures within the bays, relative to the open ocean, as characteristics favouring larval growth and survival. The observed surface water temperatures and salinities of Jeddore Harbour (Appendices A and B) averaged 15.31 °C$\pm$1.83 °C and 27.24$\pm$4.37°C, respectively. These are well within the temperature and salinity ranges reported by MacKenzie (1988) and Templeman (1936) respectively, as conducive for high rates of survival as well as enhanced larval growth and development.

There are several possible explanations to account for the paucity of post-stage 1 larvae in the Harbour. Consideration in plankton surveys must always be given to the ability of an organism to detect the net (for example, via bow-waves, noise, etc.) and subsequently avoid its path. This is not expected to affect Stage 1, 2 and 3 larvae as they are apparently not capable of unidirectional avoidance behavior until the post-larval stage (Davis 1973). Indeed, previous inshore larval lobster studies (Bibb et al. 1983; Collings et al. 1981, 1983; Harding et al. 1982; Hudon et al. 1986; Scarratt 1973 and Templeman 1939) have sampled all planktonic stages with comparable techniques to those of this study. In fact, Tremblay and Sharp (1989), used the same equipment to capture all lobster larval stages and the post-larval stage in Lobster Bay off southwestern Nova Scotia.

Stage specific mortality has been considered in the past by Fogarty et al. (1983), Harding et al. (1983) and Scarratt (1964, 1973). All suggested that lobster dispersion is by the larval stage, consequently large numbers are produced to offset possible high mortalities. The concern then, from a sampling perspective, is that post-stage 1 larval mortality rates may have been sufficiently high to significantly lower larval concentrations. Chance alone, however, would seem to suggest that at least a few of the later stages should be captured were they in the harbour, considering the many weeks of

Table 1: Total number of lobster larvae (all stage 1) captured, both per cruise and during daylight and at night , between July 21 and September 22, 1988 in Jeddore Harbour.

Date	Number of Tows	Total larvae	Larvae captured during		No. larvae per 1000m^3	
			day	night	day	night
July 21/22	7	4	3	1	0.91	0.97
28/29	7	1	0	1	0.00	0.85
Aug. 4/5	11	115	1	114	0.50	20.02
11/12	8	5	2	3	0.89	2.82
18/19	7	67	0	67	0.00	14.64
25/26	7	10	2	8	0.79	3.55
Sept. 1/2	10	5	0	5	0.00	1.85
8/9	8	0	0	0	0.00	0.00
15/16	7	0	0	0	0.00	0.00
22/23	7	1	0	1	0.00	0.81
Totals	79	208	8	200	3.09	45.51

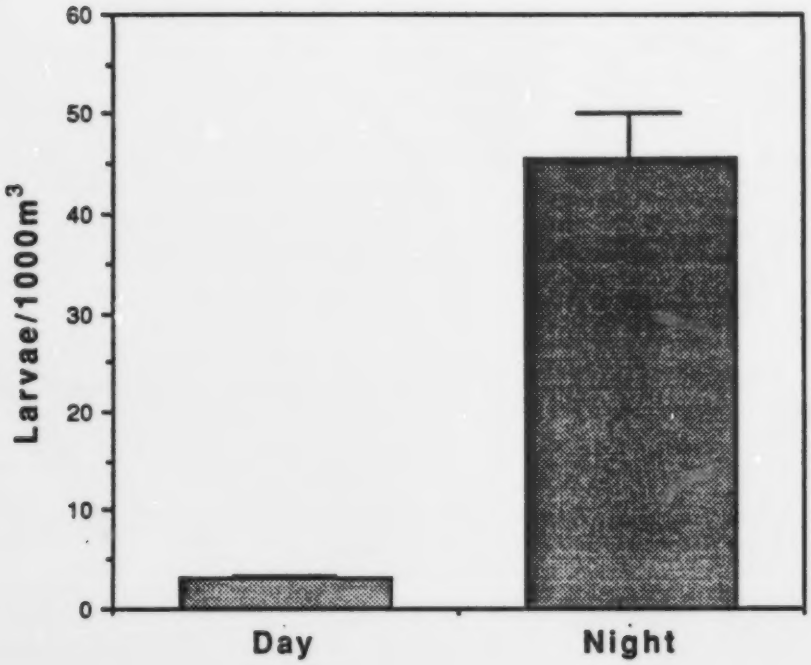

Figure 5: Total number of lobster larvae (/1000 m^3) captured during nighttime and daytime tows showed a significant difference ($P \leq 0.05$). Vertical lines represent ±1 standard error.

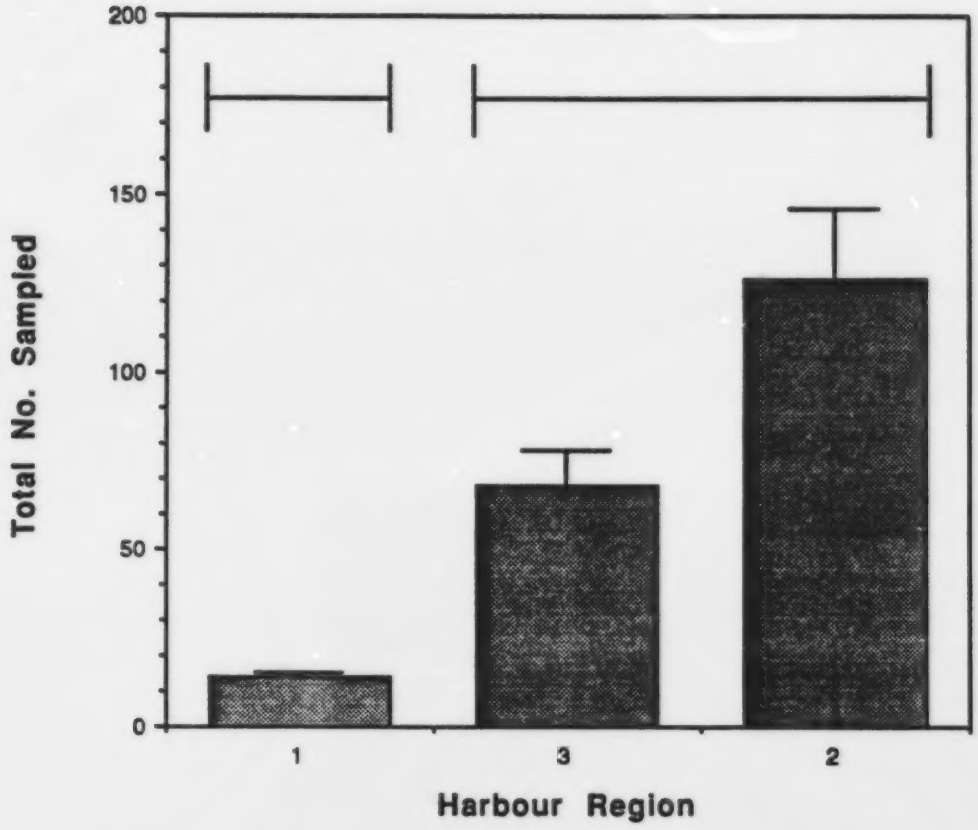

Figure 6: Number of lobster larvae sampled in each of three designated regions of Jeddore Harbour. Vertical lines represent ±1 standard error; horizontal lines represent test of significance ($P \leq 0.05$).

sampling following large catches of first stage larvae. Post-larvae occur in the upper one meter offshore (Harding et al. 1987), thus they would be expected to be caught by the present methods.

There is the possibility post-Stage 1 larvae occupied that portion of the harbour not sampled. Gear design limited thorough sampling of the shallow mussel and eelgrass beds. Able et al. (1988) suggested that such shallow beds provide a natural habitat for lobsters when they adopt a benthic lifestyle. However here it seems unlikely the stages 2 and 3 migrated to the shallows in anticipation of settling. According to Templeman and Tibbo (1945), first and second stage larvae swim away from the surface in bright sunlight; their presence therefore, in such shallow portions of the bay would eliminate vertical migrations and hence their escape from such light. Stage 1 larvae were sampled in eight of the ten cruises. Since stages 2 and 3 were reported to occupy the same areas and depths as stage 1 (Phillips and Sastry 1980; Harding et al. 1987), (Fogarty et al. 1983; Harding et al. 1982 and Scarratt 1973), we would expect to have observed at least a few in the most productive areas of the harbour, which were intensively sampled for the entire ten week period.

The inability to capture post-Stage 1 larvae may have been due to their having departed the harbour. Larval retention in Jeddore Harbour might be short, in part, due to the residence time of the water. Lauff (1967) defines estuary flushing as the rate at which water is removed from an estuary, thereby giving an estimate for the removal of a constituent (for example, pollutants, passive drifters, etc.) from the harbour to the outside waters. One might question the applicability of this concept to lobster larvae, which have the ability to swim. Ennis (1986), however, has shown that lobster larvae are relatively poor horizontal swimmers. Thus the calculated flushing rate of approximately 60 h (2.5 da) supports the "flushing" hypothesis. We propose that larvae were removed from the bay well before the first molt, which requires 6.0 da$\pm$1.0 da at 14.5°C$\pm$0.4°C, (MacKenzie 1988).

The distribution of the larvae lends further support for the flushing hypothesis. The vast majority of larvae sampled (>93%) were captured in the harbour's channel (regions 2 and 3, Fig. 1), which is the prime location for female lobsters in the process of egghatch (Jarvis, pers. comm.). The channel is located in close proximity to the harbour's mouth. Thus, once a larva is entrained in the ebb current the time required for its removal from the bay would be short as the channel current is swift due to the harbour configuration.

It would appear that larvae would develop faster were they to remain in the harbour. Caddy (1979) suggested that larvae, with the ability to regulate vertical distribution, could employ counter-currents to remain within a favourable location. There is evidence that Jeddore Harbour waters undergo strong and turbulent flows, such that the entire water column becomes thoroughly mixed. Jarvis (1989) observed little or no stratification based on temperature and salinity data from the channel waters. Thorough mixing eliminates the possibility of counter-current layers in addition to thermo- and halo-layers, thus in this harbour vertical migration would not reduce the chance of movement to the open coast.

Once outside the harbour, the larvae experience significantly lower water temperatures, and possibly less food and higher rates of predation. A mechanism for wholesale passage back into the harbour is difficult to envision.

In conclusion, the presence of Stage 1 lobster larvae within the confines of Jeddore Harbour, as well as conducive temperature and salinity ranges, lend support to the hypothesized use of such warm sheltered embayments by berried female lobsters for the enhanced growth and development of eggs and larvae. The harbour appears not to retain any larvae beyond stage 1, however, due to high flushing rates. The lack of post-stage 1 larvae, and the high flushing rate, suggests that those larvae captured within the harbour were hatched there and were likely not carried in by currents. Sampled larvae were most abundant in the neuston during a two hour time span immediately following sunset, while the horizontal distribution tended to display an aggregated behavior in deeper portions of the harbour (for example, the harbour's channel).

The key to a more stable and commercially viable lobster fishery is to better understand all aspects of this species life-cycle (for example, physiology, ecology, etc.). Although significant knowledge is available on the American lobster (Homarus americanus), much more remains to be learned. In particular, the larval and post-larval stages require much more attention. A comparison of other harbours throughout the near-shore Scotian Shelf area would be of particular interest. Consideration of harbour characteristics (for example, flushing rate) with respect to the presence or absence of the three larval stages and the post-larval stage would help in assessing the role of these warm sheltered embayments to the growth and development of lobster larvae.

ACKNOWLEDGEMENTS

The authors thank G. Sharp, for the loan of the vessel, Rapture, and P. Vass and R. Miller for providing other field equipment. R. Duggan kindly modified the mast and booms on short notice to accommodate efficient net cleaning. The following are thanked for field assistance; R. Duggan, R. Ugarte, C. Jarvis, S. Wilson, D. Roddick, and D. Duggan. Dr. I. MacLaren assisted with statistical analysis; Dr. R. Trites directed the analysis of harbour flushing, R. Duggan and G. Harding improved the manuscript through review and V. Clayton typed the manuscript for publication. John Jennex and Captain R. Pace kindly provided docking facilities.

REFERENCES

Able, K.W., K.L. Heek, M.P. Fahay, and C.T. Roman. 1988. Use of salt-marsh peat reefs by small juvenile lobsters on Cape Cod, Massachusetts. Estuaries 11 (2): 83-86.

Anonymous, Department of Fisheries and Oceans. 1988. Canadian Tide and Current Tables: Volume 1 - Atlantic Coast and Bay of Fundy: 50 p.

Anonymous. 1989. The Scotia-Fundy lobster fishery Phase One: Issues and considerations; Summary Report Communications Branch, Department of Fisheries and Oceans, Halifax, Nova Scotia, Canada, 41 p.

Bibb, B.G., R.L. Hersey, and R.A. Marcello, Jr. 1983. Distribution and abundance of lobster larvae (Homarus americanus) in Block Island Sound. U.S. Dept. of Commerce, NOAA Tech. Rep. NMFS SSRF-775: 15-22.

Caddy, J.F. 1979. The influence of variation in the seasonal temperature regime on survival of larval stages of the American lobster (Homarus americanus) in the southern Gulf of St. Lawrence. Rapp. P.-V. Reun. Cons. Int. Explor. Mer. 175: 204-216.

Cobb, J.S., D. Wang, and D.B. Campbell. 1989. Timing of settlement by postlarval lobster (Homarus americanus): Field and laboratory evidence. Journal of Crustacean Biology, 9 (1): 60-66.

Collings, W.S., C. Cooper-Sheehan, S.C. Hughes, and J.L. Buckley. 1981. Lobster larvae. In: The effects of power generation on some of the living marine resources of the Cape Cod Canal and approaches. Massachusetts Dept. Fish. Wildl. Recr. Vehicles. Div. Mar. Fish., Sandwich, Massachusetts, p. 21-97.

Collings, W.S., C. Cooper-Sheehan, S.C. Hughes, and J.L. Buckley. 1983. The spatio-temporal distribution of American lobster, Homarus americanus, larvae in the Cape Cod Canal and approaches. U.S. Dept. of Commerce. NOAA Tech. Rep. NMFS SSRF-775: p. 35-40.

Dadswell, M.J. 1979. A review of the decline of lobster (Homarus americanus) landings in Chedabucto Bay between 1956 and 1977 with a hypothesis for a possible effect by the Canso Causeway on the recruitment mechanism of eastern Nova Scotia lobster stocks. Fish. Mar. Serv. Tech. Rep. 834: 114-144.

Davis, W.J. 1973. Development of locomotor patterns in the absence of peripheral sense organs and muscles. Proc. Natl. Acad. Sci. USA 70: 954-958.

Dewolf, A.G. 1974. The lobster fishery of the Maritime provinces: economic effect of regulations. Bull. Fish. Res. Board Can. 187: 59 p.

Duggan, R.E., and J.D. Pringle. 1988. Lobster size structure and seasonal distribution in the Clam Bay area of Halifax County, Nova Scotia. Can. Atl. Fish. Sci. Adv. Comm. Res. Doc. 88/13: 21 p.

Ennis, G.P. 1975. Behavioural responses to change in hydrostatic pressure and light during larval development of the lobster, Homarus americanus. J. Fish. Res. Board Can. 32: 271-81.

Ennis, G.P. 1986. Swimming ability of larval American lobsters, Homarus americanus, in flowing water. Can. J. Fish. Aquat. Sci. 43: 2177-2183.

Fogarty, M.J., M.A. Hyman, G.F. Johnson, and C.A. Griscom. 1983. Distribution, relative abundance and seasonal production of American lobsters, Homarus americanus, larvae in Block Island Sound in 1978. U.S. Dept. of Commerce, NOAA Tech. Rep. NMFS SSRF-775: p. 23-28.

Harding, G.C., P.G. Wells, and K.F. Drinkwater. 1979. The distribution and abundance of lobster larvae (Homarus americanus) in St. Georges Bay, Nova Scotia, in 1975 and 1976 and the possible effect that the Canso Causeway has had on the Chedabucto Bay Lobster Fishery. Fish. Mar. Serv. Tech. Rep. 834 (part 3): 101-111.

Harding, G.C., W.P. Vass, and K.F. Drinkwater. 1982. Aspects of larval American lobster (Homarus americanus) ecology in St. Georges Bay, Nova Scotia. Can. J. Fish. Aquat. Sci. 39: 1117-1129.

Harding, G.C., K.F. Drinkwater, and W.P. Vass. 1983. Factors influencing the sizes of lobster stocks along the Atlantic Coast of Nova Scotia, Gulf of St. Lawrence and Gulf of Maine: a new synthesis. Can. J. Fish. Aquat. Sci. 40: 168-184.

Harding, G.C., J.D. Pringle, W.P. Vass, S. Pearre, Jr., and S.J. Smith. 1987. Vertical distribution and density movements of larval lobsters (Homarus americanus) over Brown's Bank Nova Scotia. Mar. Ecol. Prog. Ser. 41: 29-41.

Herrick, F.H. 1911. Natural history of the American Lobster. Bull. U.S. Bureau Fish. 29: 320-352.

Hudon, C., P. Fradette, P. Legendre. 1986. La repartition horizontale et verticale des larvae de homard (Homarus americanus) autour des iles de la Madelaine, golfe du Saint Laurent. Can. J. Fish. Aquat. Sci. 43: 2164-2176.

Jarvis, C. 1989. Movement patterns of late-stage ovigerous female lobsters (Homarus americanus, Milne Edwards) at Jeddore, Nova Scotia. M.Sc. Thesis, Dalhousie University, 148 p.

Lauff, G.H. 1967. Estuaries. American Association for the Advancement of Science. Baltimore, Maryland, 19-20.

Lux, F.E., G.F. Kelly, C.L. Wheeler. 1983. Distribution and abundance of larval lobsters (Homarus americanus) in Buzzards Bay, Massachusetts, during 1976-79. U.S. Dept. of Commerce, NOAA Tech. Rep. NMFS SSRF-775: 29-33.

MacKenzie, B.R. 1988. Assessment of temperature effects on interrelations between stage durations, mortality, and growth in laboratory-reared Homarus americanus Milne Edwards larvae. J. Exp. Mar. Biol. Ecol. 116: 87-98.

Phillips, B.F., and A.N. Sastry. 1980. Larval Ecology. In: The Biology and Management of Lobsters. Academic Press, Inc. New York, N.Y., 11-57.

Pringle, J.D., D.J. Robinson, G.P. Ennis, and P. Dube. 1983. An overview of the management of the lobster fishery in Atlantic Canada. Can. MS Rep. Fish. Aquat. Sci. 1701: 103 p.

Pringle, J.D., and R.E. Duggan. 1984. Latent lobster fishing effort along Nova Scotia's Atlantic Coast. Can. Atl. Fish. Sci. Adv. Comm. Res. Doc. 84/56: 21 p.

Pringle, J.D., and R.E. Duggan. 1985. An estimate of yields for oceanic Nova Scotia lobster grounds. Can. Atl. Fish. Sci. Adv. Comm. Res. Doc. 85/102: 16 p.

Robinson, D.G. 1979. Consideration of the lobster (Homarus americanus) recruitment overfishing hypothesis, with special reference to the Canso Causeway. In: Proceedings of the Canso Marine Environment Workshop (F.D. McCracken, Ed.). Fish. Mar. Serv. Tech. Rep. 834, Part 3: 77-99.

Scarratt, D.J. 1964. Abundance and distribution of lobster larvae (Homarus americanus) in Northumberland Strait. J. Fish. Res. Board Can. 21: 661-680.

Scarratt, D.J. 1973. Abundance, survival, and vertical and diurnal distribution of lobster larvae in Northumberland Strait, 1962-63, and their relationships with commercial stocks. J. Fish. Res. Board Can. 30: 1819-1824.

Siegel, S. 1956. Nonparametric Statistics: For the Behavioural Sciences. McGraw-Hill Book Company, Inc. 312 p.

Smith, G.F.M. 1937. Plankton tows for lobster larvae 1937. Biol. Board Can. MS Rep. 193 B: 1-4.

Stasko, A.B. 1980. Tagging and lobster movements in Canada. Can. Tech. Rep. Fish. Aquat. Sci. 932: 141-150.

Templeman, W. 1936. The influence of temperature, salinity, light and food conditions on the survival and growth of the larvae of the lobster (Homarus americanus). J. Biol. Board Can. 2: 485-497.

Templeman, W. 1937. Habits and distribution of larval lobster (Homarus americanus). J. Biol. Board Can. 3: 343-347.

Templeman, W. 1939. Investigation into the life history of the lobster (Homarus americanus) on the west coast of Newfoundland, 1938. Nfld. Dept. Nat. Resour. Res. Bull. (Fish). 7: 33-52.

Templeman, W., and S.N. Tibbo. 1945. Lobster investigations in Newfoundland 1938 to 1941. Nfld. Dept. Nat. Resour. Res. Bull. (Fish). 16: 60-98.

Tranter, T.J., and P.E. Smith. 1968. Filtration performances, p. 27-56. Zooplankton sampling, Paris, Unesco, 2nd impr. 1974. (Unesco Monographs on Oceanographic methodology, No. 2).

Tremblay, D.M., and G.J. Sharp. 1989. Lobster larval abundance in Lobster Bay, Yarmouth Co., Nova Scotia-1983. Proc. N.S. Inst. Sci. Vol. 38(2): 43-53.

Wells, P.G. 1976. Effects of Venezuelan crude oil on young stages of the American lobster, Homarus americanus. Ph.D. Thesis, University of Guelph.

Wells, P.G., and J.B. Sprague. 1976. Effects of crude oil on American lobster (Homarus americanus) larvae in the laboratory. J. Fish. Res. Board Can. 33: 1604-1614.

Wharton, W.G., and K.H. Mann. 1981. Relationship between destructive grazing by sea-urchin, Strongylocentrotus droebachiensis, and the abundance of American lobster, Homarus americanus, on the Atlantic coast of Nova Scotia. Can J. Fish. Aquat. Sci. 38: 1339-1349.

Wilder, D.G. 1953. The growth rate of the American lobster (Homarus americanus). J. Fish. Res. Board Can., Vol. 10: 371-404.

Wilkinson, L. 1987. Systat: The System for Statistics. Evanston, Il.: Systat, Inc.

Appendix A. Surface water temperature measurements (°C) for 72 of 79 plankton tows conducted between July 21 and September 22, 1988 in Jeddore Harbour.

	Tow no.										
	1	2	3	4	5	6	7	8	9	10	11
July 21	---	---	---	---	---	---	---	**	**	**	**
July 28	16.8	15.9	14.2	14.0	16.0	16.8	17.0	**	**	**	**
August 4	15.9	16.8	16.6	14.5	14.5	14.4	15.1	15.0	16.5	16.1	15.9
August 11	16.6	15.8	16.6	17.3	17.8	17.8	17.9	17.1	**	**	**
August 18	15.2	15.1	14.5	15.0	14.9	15.0	15.0	**	**	**	**
August 25	16.0	16.3	16.3	16.6	16.7	16.8	16.3	**	**	**	**
September 1	18.0	17.9	18.0	18.0	17.6	17.5	17.5	17.4	17.0	17.6	**
September 8	16.2	14.5	13.5	14.2	15.2	15.2	16.2	16.7	**	**	**
September 15	12.1	11.9	12.2	12.3	12.6	12.1	10.8	**	**	**	**
September 22	13.2	12.9	13.2	13.1	13.0	12.9	12.7	**	**	**	**

--- no temperature measurement made

** no tow conducted

Appendix B. Surface salinity measurements ($^{o}/oo$) for 51 or 79 plankton tows conducted between July 21 and September 22, 1988 in Jeddore Harbour.

	Tow no.										
	1	2	3	4	5	6	7	8	9	10	11
July 21	---	---	---	---	---	---	---	**	**	**	**
July 28	---	---	---	---	---	---	---	**	**	**	**
August 4	---	---	---	---	---	---	---	---	---	---	---
August 11	26.8	28.0	26.2	26.0	26.0	---	---	---	**	**	**
August 18	28.0	27.5	27.0	27.0	27.5	27.0	27.0	**	**	**	**
August 25	29.0	29.0	28.0	27.5	28.0	27.0	26.0	**	**	**	**
September 1	29.0	28.0	27.5	27.0	27.5	27.0	28.0	28.5	29.0	28.0	**
September 8	28.0	29.5	29.5	29.0	27.5	27.0	27.0	26.5	**	**	**
September 15	28.0	27.0	27.0	27.0	27.0	27.5	27.5	**	**	**	**
September 22	29.0	28.0	27.5	27.5	28.5	28.0	27.5	**	**	**	**

--- no salinity measurement made

** no tow conducted

Appendix C. Subsurface light intensity measurements ($\mu E\ m^{-2}\ s^{-1}$) for 63 of 79 plankton tows conducted between July 21 and September 22, 1988 in Jeddore Harbour.

	Tow no.										
	1	2	3	4	5	6	7	8	9	10	11
July 21	---	---	---	---	---	0	0	**	**	**	**
July 28	275	---	---	100	0	0	0	**	**	**	**
August 4	500	800	650	200	45	1.5	0	0	0	0	0
August 11	800	620	550	2	0	0	0	0	**	**	**
August 18	180	550	190	0	0	0	0	**	**	**	**
August 25	---	---	---	0	0	0	0	**	**	**	**
September 1	---	---	---	---	0	0	0	0	0	0	**
September 8	850	750	450	0	0	0	0	0	**	**	**
September 15	400	175	150	45	5	0	0	**	**	**	**
September 22	600	400	90	11	0	0	0	**	**	**	**

--- no light intensity measurement made

** no tow conducted

Appendix D. Total larval catch abundance and number of larvae per 1000 m^3 (in brackets) for each of the 79 plankton tows conducted between July 21 and September 22, 1988 in Jeddore Harbour.

	Tow no.										
	1	2	3	4	5	6	7	8	9	10	11
July 21	2.0 (0.91)	1.0 (0.47)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	1.0 (0.49)	0.0 (0.00)	**	**	**	**
July 28	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	1.0 (0.43)	0.0 (0.00)	**	**	**	**
August 4	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	1.0 (0.50)	0.0 (0.00)	0.0 (0.00)	106.0 (37.50)	6.0 (5.25)	2.0 (0.93)	0.0 (0.00)	0.0 (0.00)
August 11	0.0 (0.00)	1.0 (0.46)	0.0 (0.00)	1.0 (0.44)	0.0 (0.00)	0.0 (0.00)	3.0 (1.41)	0.0 (0.00)	**	**	**
August 18	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	33.0 (15.61)	34.0 (13.67)	**	**	**	**
August 25	1.0 (0.40)	1.0 (0.39)	0.0 (0.00)	0.0 (0.00)	8.0 (3.55)	0.0 (0.00)	0.0 (0.00)	**	**	**	**
September 1	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	5.0 (1.85)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	**
September 8	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	**	**	**	**
September 15	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	**	**	**	**
September 22	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	1.0 (0.81)	0.0 (0.00)	**	**	**	**

** no tow conducted

Appendix E: The date (dd/mm/yy), time (start of tow), length (in minutes) and location of each of the 79 tows conducted between July 21 and September 22, 1988 in Jeddore Harbour.

TOW #	DATE	TIME	LGTH	LOC*	TOW #	DATE	TIME	LGTH	LOC*
1	21/07/88	1440	20	4	46	25/08/88	2230	25	6
2	21/07/88	1535	20	1	47	25/08/88	2355	25	10
3	21/07/88	1620	25	5	48	01/09/88	1554	25	14
4	21/07/88	1710	30	7	49	01/09/88	1648	25	9
5	21/07/88	1920	25	7	50	01/09/88	1748	25	9
6	21/07/88	1955	20	4	51	01/09/88	1833	25	5
7	21/07/88	2040	25	11	52	01/09/88	2022	25	6
8	28/07/88	1555	25	4	53	01/09/88	2120	25	10
9	28/07/88	1645	20	5	54	01/09/88	2205	25	10
10	28/07/88	1739	21	9	55	01/09/88	2253	25	11
11	28/07/88	1820	20	7	56	01/09/88	2340	25	13
12	28/07/88	2100	20	7	57	01/09/88	0040	22	8
13	28/07/88	2145	20	5	58	08/09/88	1646	25	9
14	28/07/88	2230	20	4	59	08/09/88	1738	25	11
15	04/08/88	1555	25	4	60	08/09/88	1830	25	11
16	04/08/88	1630	20	1	61	08/09/88	2050	25	13
17	04/08/88	1710	20	1	62	08/09/88	2140	25	14
18	04/08/88	1745	20	5	63	08/09/88	2240	25	9
19	04/08/88	1950	25	13	64	08/09/88	2338	25	10
20	04/08/88	2035	20	11	65	08/09/88	0038	25	8
21	04/08/88	2115	20	9	66	15/09/88	1612	27	15
22	04/08/88	2155	25	1	67	15/09/88	1702	12	14
23	04/08/88	2240	20	-	68	15/09/88	1737	25	13
24	04/08/88	2315	20	4	69	15/09/88	1820	25	9
25	04/08/88	2400	25	6	70	15/09/88	1921	25	9
26	11/08/88	1620	25	5	71	15/09/88	2009	45	12
27	11/08/88	1715	25	9	72	15/09/88	2120	45	14
28	11/08/88	1810	25	1	73	22/09/88	1615	25	5

.../continued

Appendix E. continued

TOW #	DATE	TIME	LGTH	LOC*	TOW #	DATE	TIME	LGTH	LOC*
29	11/08/88	2025	25	8	74	22/09/88	1722	15	9
30	11/08/88	2110	25	8	75	22/09/88	1810	15	9
32	11/08/88	2335	25	4	77	22/09/88	2110	28	14
33	11/08/88	0035	25	3	78	22/09/88	2201	25	12
34	18/08/88	1655	24	12	79	22/09/88	0032	10	-
35	18/08/88	1837	25	10					
36	18/08/88	1955	28	2					
37	18/08/88	2040	25	5					
38	18/08/88	2135	25	9					
39	18/08/88	2220	25	11					
40	18/08/88	2315	25	13					
41	25/08/88	1652	25	9					
42	25/08/88	1755	25	11					
43	25/08/88	1940	25	11					
44	25/08/88	2030	25	12					
45	25/08/88	2118	25	10					

* Numbers indicate one of 15 representative tows shown on the map of the following page.
Tow #23 and #79 were in the channel, but unspecified as to what part.